

Date: August 4, 2000

JC901 U.S. PTO

Atty Docket No. NPO0005

ASSISTANT COMMISSIONER FOR PATENTS
Washington, DC 20231

08/04/00

Sir:

Transmitted herewith for filing is the patent application of

Inventor: Keiji Ishibashi

For: A HOT ELEMENT CVD APPARATUS AND A METHOD FOR REMOVING A DEPOSITED FILM

Priority: Priority to Japanese Application No. 11-222088, filed August 5, 1999, is hereby claimed under the provisions of 35 U.S.C. §119.

Enclosed are:

[XX] Express Mail Cover Letter
 [XX] New Application Transmittal Page - In Duplicate
 [XX] Specification (14 pages), Claims (2 pages) and Abstract (1 page)
 [XX] Preliminary Amendment (4 pages)
 [XX] Substitute Abstract of the Disclosure (1 page)
 [XX] Substitute Specification (12 pages)
 [XX] Redline Specification (13 pages)
 [XX] Verification of Translation
 [XX] Declaration and Power of Attorney for Patent Application
 [XX] Two (2) Pages of Formal Drawings
 [XX] Claim for Priority and Priority Document No. JP11-222088
 [XX] Assignment and Assignment Cover Sheet
 [XX] Information Disclosure Statement
 [XX] PTO Form 1449
 [XX] Five(5) Prior Art References
 [XX] Return Post Card - In duplicate
 [XX] Fees - \$730.00

The filing fee has been calculated as follows:

			SMALL ENTITY		OTHER THAN SMALL ENTITY	
#1	#2		RATE	FEE	RATE	FEE
FOR:	FILED	EXTRA				
BASIC FEE				\$ 345.00		\$ 690.00
TOTAL CLAIMS	10	- 20 = 0	x \$ 9 =	\$ *	OR x \$ 18 =	\$ *
INDEP CLAIMS	2	- 3 = 0	x \$ 39 =	\$ *	OR x \$ 78 =	\$ *
MULTIPLE DEPENDENT CLAIMS			+ \$ 130 =	\$ *	OR + \$ 260 =	\$ *
If the difference in Col. 1 is less than zero, enter "0" in Col. 2.			TOTAL	\$ *	OR TOTAL	\$ 690.00
ASSIGNMENT RECORDING FEE (\$40)				\$ *		\$ 40.00
TOTAL ENCLOSED				\$ *		\$ 730.00

[] Please charge my Deposit Account No. 02-0385, BAKER & DANIELS, the amount of \$ _____.
 A duplicate copy of this sheet is enclosed.

[XX] A check in the amount of \$ 730.00 to cover the filing fee is enclosed. (Check No. 048349)

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[X] Any additional filing fees required under 37 CFR 1.16.

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[X] Any patent application processing fees under 37 CFR 1.17.

[] The issue fee set in 37 CFR 1.18 at or before mailing of the Notice of Allowance, pursuant to 37 CFR 1.311(b).

[X] Any filing fees under 37 CFR 1.16 for presentation of extra claims.

Respectfully submitted,

Anthony Niewyk, Reg. No. 24,871
 Attorney for Applicant

BAKER & DANIELS
 111 East Wayne Street, Suite 800
 Fort Wayne, IN 46802
 Telephone: 219-424-8000/Facsimile: 219-460-1700

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10784 U.S. PTO
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Date: August 4, 2000

Box Patent Application
Assistant Commissioner for Patents
Washington, DC 20231

Re: Application for United States Letters Patent

APPLICANT: Keiji Ishibashi

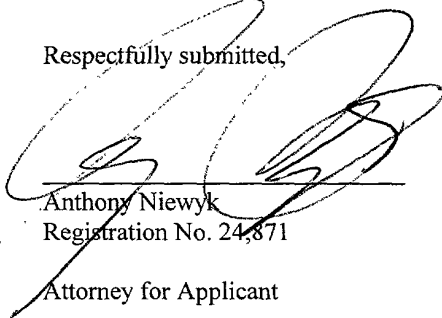
TITLE OF INVENTION: A HOT ELEMENT CVD APPARATUS AND A METHOD FOR
REMOVING A DEPOSITED FILM

Sir:

Forwarded herewith is the above-identified application, consisting of the following:

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New Application Transmittal Page - In Duplicate
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Respectfully submitted,


Anthony Niewyk
Registration No. 24,871

Attorney for Applicant


BAKER & DANIELS
111 EAST WAYNE STREET, SUITE 800
FORT WAYNE, IN 46802
TELEPHONE: 219-424-8000
FACSIMILE: 219-460-1700

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of)	
Keiji Ishibashi)	Group: Unknown
Serial No. Unknown)	
Filed: August 4, 2000)	Examiner: Unknown
Title: A HOT ELEMENT CVD APPARATUS)	
AND A METHOD FOR REMOVING)	Customer No. 00832
A DEPOSITED FILM)	

PRELIMINARY AMENDMENT

Box Patent Application
Assistant Commissioner for Patents
Washington, DC 20231

Sir:

Prior to the examination of the above-identified application, please amend the application as follows:

IN THE TITLE

Delete the title and substitute therefor --A HOT ELEMENT CVD APPARATUS AND A METHOD FOR REMOVING A DEPOSITED FILM--.

IN THE ABSTRACT

Delete the Abstract and substitute therefor the Abstract attached hereto as a separate sheet.

IN THE SPECIFICATION

Please cancel the specification and replace it with the substitute specification submitted herewith. Also submitted for the Examiner's convenience is a copy of the original specification which shows deleted material with a line through it and added material underlined. In accordance with the requirements of 37 CFR § 1.125(b), the undersigned submits that the substitute specification includes no new matter.

IN THE CLAIMS

Please cancel claims 1-10, and in place thereof substitute new claims 11-20 as follows:

--11. A method for removing a deposited film inside a chamber which comprises:
providing a hot element in the chamber, the hot element having at least a surface
which comprises platinum;

exhausting said chamber;

5 heating the hot element;

supplying a cleaning gas into the chamber;

contacting the cleaning gas with the heated hot element to decompose and/or
activate the cleaning gas and generate an activated species therefrom;

10 allowing the activated species to convert the deposited film into a gaseous
substance; and

removing the gaseous substance from the chamber.- -

--12. The method according to claim 11, wherein said chamber comprises a CVD
apparatus and the method further comprises:

heating the hot element;

15 supplying a material gas to the chamber;

contacting the material gas with the hot element to cause decomposition and/or
activation of the material gas by said hot element; and

forming the deposited film which comprises at least one element from said
material gas on a substrate.- -

20

--13. The method according to claim 11, wherein at least a part of a surface of an
inner structure of said chamber is covered with platinum.- -

--14. The method according to claim 12, wherein at least a part of the surface of
an inner structure of said chamber is covered with platinum.- -

25 - -15. The method according to claim 11, wherein said cleaning gas is a gas containing at least one of fluorine (F₂), chlorine (Cl₂), nitrogen trifluoride (NF₃), carbon tetrafluoride (CF₄), hexafluoroethane (C₂F₆), octafluoropropane (C₃F₈), carbon tetrachloride (CCl₄), pentafluorochloroethane (C₂ClF₅), trifluorochlorine (ClF₃), trifluorochloromethane (CClF₃), and sulfur hexafluoride (SF₆), and mixtures thereof- -

 - -16. The method according to claim 12, wherein said cleaning gas is a gas containing at least one of fluorine (F₂), chlorine (Cl₂), nitrogen trifluoride (NF₃), carbon tetrafluoride (CF₄), hexafluoroethane (C₂F₆), octafluoropropane (C₃F₈), carbon tetrachloride (CCl₄), pentafluorochloroethane (C₂ClF₅), trifluorochlorine (ClF₃),
5 trifluorochloromethane (CClF₃), sulfur hexafluoride (SF₆), and mixtures thereof.- -

 - -17. A CVD apparatus comprising:
 a chamber having a material gas inlet and a cleaning gas inlet;
 a hot element located in the chamber, the hot element having a surface which comprises platinum;
5 means for exhausting the chamber;
 a source of material gas coupled to the material gas inlet;
 means for heating the hot element to a first temperature sufficient to decompose and/or activate the material gas:
 a source of cleaning gas coupled to the cleaning gas inlet; and
10 means for heating the hot element to a second temperature sufficient to decompose and/or activate the cleaning gas to generate an activated species therefrom which active species is able to convert a film deposited inside said chamber to gaseous substance, which gaseous substance can be removed from the chamber by exhausting the chamber.- -

 - -18. The CVD apparatus according to claim 17, wherein at least a part of a surface of an inner structure of said chamber is covered with platinum.- -

--19. The CVD apparatus according to claim 17, wherein an electrode for plasma generation is disposed in said chamber.- -

--20. The CVD apparatus according to claim 18, wherein an electrode for plasma generation is disposed in said chamber.- -

• • • R E M A R K S • • •

By the present Preliminary Amendment, the specification, claims and abstract have been revised to more clearly describe applicant's invention in accordance with the requirements of 35 U.S.C. § 112.

Care has been taken so as to avoid the addition of new matter in the specification, claims and abstract.

Entry of the present Preliminary Amendment prior to the examination of the application is respectfully requested.

Variable	Mean	SD	Min	Max
Age	35.2	12.5	18	65
Gender	Male	10.1	0	20
Marital Status	Married	15.3	0	30
Education	High School	5.2	0	12
Income	\$25,000	\$15,000	\$5,000	\$50,000
Health Status	Good	12.8	0	25
Stress Level	Low	8.5	0	20
Life Satisfaction	High	18.2	0	35
Work-Life Balance	Good	14.5	0	30
Family Support	Strong	16.7	0	35
Community Involvement	Active	11.3	0	25
Personal Growth	High	19.5	0	40
Relationship Quality	Excellent	20.1	0	40
Overall Well-being	Very Good	22.3	0	45

Respectfully submitted,

MSG/pad/139278 1

Date: August 4, 2000

ABSTRACT OF THE DISCLOSURE

A method for efficiently and completely removing a film deposited inside a film forming chamber and a CVD apparatus having a hot element to which an in-situ cleaning method can be applied, and an in-situ cleaning method.

The removal method of this invention comprises a method for removing a film deposited inside a chamber which can be exhausted and/or on a member placed in the chamber, wherein after the chamber is exhausted, a hot element, at least the surface of which is composed of platinum, disposed in said vacuum chamber, is heated at a prescribed temperature and a cleaning gas which is decomposed and/or activated by the hot element to generate an activated species that converts the deposited film into gaseous substance is introduced into the chamber.

A HOT ELEMENT CVD APPARATUS AND
A METHOD FOR REMOVING A DEPOSITED FILM

BACKGROUND OF THE INVENTION

1. Field of the Invention.

This invention relates to a CVD apparatus for forming a film by using a hot element set at a prescribed temperature and a method for removing a deposited film, and particularly to a hot element CVD apparatus in which an in-situ cleaning is applied to and its cleaning method.

2. Description of the Invention.

In the manufacturing process of semiconductor devices such as an LSI (large scale integrated circuit), display devices such as an LCD (liquid crystal display) and the like, a chemical vapor deposition (CVD) method is widely used for forming a variety of thin films on a substrate.

As such a CVD method, a plasma CVD method which utilizes a plasma to decompose and/or activate a material gas to form a film on a substrate and a thermal CVD method which utilizes the heat of a substrate to cause a reaction of a material gas and form a film on a substrate are well know. In addition to these methods, there is another CVD method in which a material gas is decomposed and/or activated to form a film by a hot element set at a prescribed high temperature. This CVD method is called "a hot element CVD method" hereinafter.

A CVD apparatus to carry out this method is constructed so that a hot element made of a metal having a high melting point such as tungsten and a substrate are disposed in a processing vacuum chamber, and a material gas is introduced into the chamber while the hot element is maintained at a temperature of about 1000-1800°C . The material gas introduced in the chamber is decomposed and/or activated to generate activated species when passing over the surface of the hot element. The activated species reaches the substrate and forms a thin film on the surface of the substrate. Of such a hot element CVD method, one using a wire as a hot element is referred to as a Hot-Wire CVD method, and one that is thought to be utilizing the catalytic reaction of a hot element in decomposition or activation process of the material gas is referred to as a Catalytic-CVD (or cat-CVD) method.

In the hot element CVD method, the decomposition or activation reaction of the material gas occurs when the gas passes over the surface of the hot element. Therefore, the substrate temperature can be lowered as compared with a thermal CVD method in which such a reaction is caused to occur only by the heat of the substrate. And unlike a plasma CVD method, the substrate is free from the damages caused by plasma. For these reasons, the hot element CVD method is expected to be a promising film forming method of semiconductor devices and display devices of the next generation, which will have higher integration and higher functions.

As the film formation is made on a substrate, a film is also deposited on the inner structures of the film forming apparatus in any film forming method including CVD methods mentioned above. The film deposited on the inner structures peels off when it becomes thick, which produces particles. The particles thus produced may be incorporated in the film on the substrate or adhere to the surface of the film, which causes the defect in the device and reduces production yield of the device.

In order to avoid these problems, the deposited film on the inner structures should be periodically removed before peeling off in the repetition of film formation.

One method often used for preventing the generation of particles due to the peeling-off of the deposited film is to cover the inner surfaces of the apparatus with sheets or members on which the films can be deposited instead of on inner surfaces in the apparatus, and to periodically exchange these sheets or members. However, since the deposition takes place even inside the narrow gaps of inner structure or on the hidden side of the sheets or members in the case of, e.g., the CVD apparatus. It is impossible to completely prevent the generation of particles.

In contrast, as a method for removing a film deposited inside the film forming chamber, there is a method called an in-situ cleaning method in which a cleaning gas is introduced into the chamber and is made to react with deposited films with the aid of energy of plasma or heat to generate gaseous substances which can be exhausted.

Since the in-situ cleaning method is carried out without exposing the inside of the chamber to the atmosphere, the continuous and stable production of thin films having a prescribed characteristic becomes available. In addition, since neither the exchange of the sheets or members nor the operation of exhausting the chamber from the atmospheric

pressure to a prescribed pressure is necessary, the time for the cleaning process is remarkably shortened. Thus, this method has an advantage in increasing the productivity.

Moreover, this method makes it possible to remove even the film deposited inside the narrow gaps and effectively suppress the generation of particles.

5 When the in-situ cleaning method is applied to a plasma CVD apparatus used for forming, for example, a silicon film or a silicon nitride film, a cleaning gas such as NF_3 , CF_4 or CCl_4 is introduced into the processing chamber and the plasma is generated at a proper time after the film formation has been repeatedly carried out. The cleaning gas is decomposed and/or activated by the plasma to react with a deposited film. A silicon film is converted to silicon tetrafluoride (SiF_4) or silicon tetrachloride (SiCl_4) and a silicon nitride film is to SiF_4 or SiCl_4 and nitrogen (N_2). Since these gaseous substances are to be exhausted, the deposited film, consequently, can be removed.

10 In contrast, when a cleaning gas such as ClF_3 that is easily decomposed by heat is employed, plasma is not necessary. The deposited film can also be converted to gaseous substances merely by heating the chamber. However, the chamber must be heated above 200°C in order to obtain a practical removal rate, which may cause the degradation of vacuum seals and substantially lengthens the cleaning time because it takes long time to heat and cool the chamber.

15 As has been mentioned, the in-situ cleaning of the film forming chamber is a very important process that is used to stabilize and continuously form a film with prescribed characteristics. Therefore, the present inventor attempted to apply the in-situ cleaning method to a promising hot element CVD apparatus and found that the convention in-situ cleaning methods have a problem in that a hot element made of metal having a high melting point reacts with the cleaning gas, and the wire becomes thin. That is, in this attempt, there were placed electrodes for the plasma generation in the processing chamber, the cleaning gas was introduced and then plasma is generated to carry out the cleaning. Although the deposited film could be removed, the hot element was also etched so that its diameter decreases. As a result, the prescribed exothermic characteristics could not be obtained in the next film formation.

20 25 30 A ClF_3 gas as a cleaning gas was introduced into the film forming chamber which was heated to 200°C by using a heater installed outside. The hot element similarly reacted with the cleaning gas and its diameter decreased.

Thus, conventional in-situ cleaning methods cannot be directly applied to a hot element CVD apparatus. However, since in-situ cleaning is desired for the continuous and stable production of films, further examination on the structure of the hot element CVD apparatus and the cleaning condition were made to establish in-situ cleaning technology is applicable to the hot element CVD apparatus.

SUMMARY OF THE INVENTION

This invention has been completed for the first time based on the above-mentioned knowledge and discovery. An object of this invention is to provide a method for efficiently and completely removing a film deposited even on the surface of a member having a complicated shape without providing a heating means for heating the member.

Another object of this invention is to provide an in-situ cleaning method for a hot element CVD apparatus which enables removal of a film deposited inside the apparatus without allowing the inside of the apparatus to be exposed to the atmosphere. Another purpose of this invention is to provide a hot element CVD apparatus to which an in-situ cleaning is applied.

A method for removing a deposited film according to the present invention comprises a method for removing a film deposited inside a chamber, which chamber can be exhausted and/or have a member placed therein, wherein after said chamber is exhausted, a hot element, at least the surface of which is composed of platinum, disposed in said chamber, is heated to a prescribed temperature and a cleaning gas which is decomposed and/or activated by said hot element to generate an activated species that converts said film into a gaseous substance is introduced into said chamber.

The chamber is part of a CVD apparatus which decomposes and/or activates a material gas by said hot element and deposits a film containing at least one element of said material gas on a substrate.

By making the surface of a hot element with platinum, it becomes possible to substantially prevent the reaction of the cleaning gas with the hot element and therefore prevent any decrease in, e.g., the diameter of, the hot element. Moreover, a hot element that is made of platinum at least at its surface, makes it possible to efficiently decompose and/or activate the cleaning gas and generate activated species at a relatively low temperature and thereby effectively remove films deposited inside the chamber. The activated species thus generated seems to have such a long lifetime that even films deposited on a complicated

shape or the inside of the pipe can be removed. In addition, the in-situ cleaning which is desired for the continuous formation of films with high characteristics can be applied to a hot element CVD apparatus.

This invention also involves covering at least a part of the surface of the inner structure of said chamber with platinum.

The inner structures except for the hot element are corroded and etched by the cleaning gas. However, the corrosion of the inner structures does not influence the film forming performance or the removal performance of deposited films since these structures are generally very thick compared with a hot element. Nevertheless, if the performance of the inner structures such as a measurement element, a sensor and the like is deteriorated by the contact of the cleaning gas, it is desirable to cover these structures with platinum so as to prevent contact of these structures with the cleaning gas. A current lead member, for example, may also be covered with platinum when thin rod is used therefore.

In this invention, said cleaning gas comprises fluorine (F_2), chlorine (Cl_2), nitrogen trifluoride (NF_3), carbon tetrafluoride (CF_4), hexafluoroethane (C_2F_6), octafluoropropane (C_3F_8), carbon tetrachloride (CCl_4), pentafluorochloroethane (C_2ClF_5), trifluorochlorine (ClF_3), trifluorochloromethane ($CClF_3$), or sulfur hexafluoride (SF_6).

These gases are sufficiently decomposed and/or activated with the aid of a hot element set at a prescribed temperature, and convert the deposited films to gaseous substances, resulting in efficiently removing the deposited film.

A CVD apparatus of this invention comprises a hot element CVD apparatus for forming a film containing at least one element of a material gas on a substrate. The CVD apparatus includes a process chamber able to be exhausted, an inlet for material gas, and a hot element able to be set at a prescribed temperature disposed in said chamber. In use, said material gas is decomposed and/or activated by said hot element. At least the surface of said hot element is composed of platinum. The CVD apparatus also includes a gas supply system that supplies a cleaning gas which is decomposed and/or activated by said hot element to generate activated species which converts a film deposited inside said chamber to a gaseous substance which is removed without exposing the inside of said chamber to the atmosphere.

In this invention, the hot element is fabricated so as not to react with a cleaning gas. This makes it possible to carry out the cleaning only by introducing the cleaning gas and

heating said hot element after film formations. Accordingly, an in-situ cleaning of the apparatus can be realized.

An electrode for plasma generation may be disposed in said chamber. Since the hot element will not react with a cleaning gas or plasma, a conventional plasma cleaning method can be employed. Moreover, in the decomposition or activation of the gas, both the plasma and the heat of the hot element may be simultaneously employed. This increases the degree of freedom of the film formation and cleaning conditions, and therefore contributes to further improvements of film characteristics and cleaning efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

The above mentioned and other features and objects of this invention, and the manner of attaining them, will become more apparent and the invention itself will be better understood by reference to the following description of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a conceptual diagram showing a configuration example of a film forming apparatus employing a hot element CVD method, in which apparatus an in-situ cleaning method according to the present invention is applied.

Fig. 2 is a conceptual plan view showing a configuration of hot element 3 shown in Fig. 1.

Fig. 3 is a sectional view of hot element 3 taken along the a-a' line.

Corresponding reference characters indicate corresponding parts throughout the several views. Although the drawings represent embodiments of the present invention, the drawings are not necessarily to scale and certain features may be exaggerated in order to better illustrate and explain the present invention. The exemplification set out herein illustrates embodiments of the invention, in several forms, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiments disclosed below are not intended to be exhaustive or limit the invention to the precise forms disclosed in the following detailed description. Rather, the embodiments are chosen and described so that others skilled in the art may utilize its/their teachings.

The preferred embodiments of this invention will be described below by referring to the accompanying drawings.

Fig. 1 is a conceptual diagram showing a structural example of a hot element CVD apparatus, in which apparatus an in-situ cleaning method according to the present invention is applied.

A film forming apparatus shown in Fig. 1 comprises a processing vacuum chamber 1, an exhaust system 11 for exhausting the processing vacuum chamber 1, gas supplying systems 23, 25 for supplying a material gas for the film formation and a cleaning gas, and a gate valve 5 through which a substrate is transferred. In processing vacuum chamber 1, surfaces of a gas supply vessel 2 connected with gas supply system 23, 25, a substrate holder 4, and a hot element 3, are made of platinum.

The introduction of a material gas and a cleaning gas to gas supply vessel 2 is switched by valves 22, 24. The feed rate of these gases is controlled by a respective flow controller (not illustrated) provided in each of gas supply systems 23, 25. Gas supply vessel 2 has a hollow structure and a plurality of gas outlets 210 in the plane that faces substrate holder 4. The exhaust system 11 is connected to processing vacuum chamber 1 through a main valve 12 having an exhaust speed regulation function by which the pressure inside the processing chamber is controlled.

A support member 31 holds hot element 3 that is connected to an energy supply mechanism 30 for controlling the temperature of hot element 3. As an energy supply mechanism, a DC or AC power source is, in general, employed. The hot element is heated and maintained at a prescribed temperature by an electric current to decompose and/or activate a material gas during a film formation process and a cleaning gas during a cleaning process, which efficiently brings about the film formation and the cleaning.

Fig. 2 is a conceptual plan view showing a configuration of hot element 3 shown in Fig. 1. In this case, hot element 3 is fabricated with a wire member formed in saw tooth shape and is held by a support member 31.

The hot element that has a platinum layer on the surface of a substrate member is described in detail by referring to Fig. 3. Fig. 3 is a sectional view of hot element 3 taken along the a-a' line of Fig. 2.

As shown in Fig. 3, the hot element comprises a substrate member 301 and a coating layer 302 formed thereon. There is no particular restriction on the material of the substrate member, but a material which has a higher melting point than platinum is preferably employed such as tungsten, tantalum, niobium, carbon, iridium, molybdenum or rhodium,

silicon carbide, PBN (pyrolitic boron nitride), alumina and the like. The coating layer 302 of platinum is formed by a method of electron-beam evaporation, sputtering, plating, lining or the like.

It is also possible to make whole hot element with platinum.

Next, the method of the film formation and the cleaning will be explained by using the apparatus shown in Fig. 1.

(Film formation)

First, a substrate is transferred into processing vacuum chamber 1 through gate valve 5 from a load lock chamber (not illustrated) and is placed on substrate holder 4. After processing vacuum chamber 1 is evacuated to a prescribed pressure by exhaust system 11, energy is supplied to hot element 3 from a DC or AC power source as an energy supply mechanism 30 to maintain hot element at a prescribed temperature. This temperature is usually determined, depending on the type of a film to be formed and a material gas; for example, a temperature around 1000°C is used for forming a silicon film with silane (SiH_4) and hydrogen (H_2).

Then, valve 22 is opened and the material gas is introduced into the processing vacuum chamber at a prescribed flow rate. The pressure inside the processing vacuum chamber is set at a prescribed pressure by the exhaust speed regulation function of main valve 12.

The material gas supplied into gas supply vessel 2 is blown off through gas outlets 210 in the direction of hot element 3, and is decomposed and/or activated by the catalytic action of the platinum of the hot element maintained at a high temperature to generate activated species. The activated species reaches the substrate and the film is deposited on it. When the thickness of the film on the substrate reaches a predetermined value, the material gas and the energy to the hot element are cut off. After the chamber is evacuated, the substrate is carried to the load lock chamber through gate valve 5 to finish the film formation.

(Cleaning)

The repetitions of the film formation mentioned above also cause the film to be deposited on the inner surface of the processing vacuum chamber, the substrate holder, the gas supply vessel, the support member and the like. When this deposited film becomes thick, it will peel off to produce particles. The particles may be entrapped in the film during the film formation or may adhere to the surface of the film, which deteriorates the characteristics

of the film or causes defects in devices. Therefore, the following cleaning treatment should be made before the film becomes thick and begins to peel off and produce particles. The film thickness of a deposited film may be monitored with the aid of an optical sensor or estimated from the total film forming time.

5 In the cleaning process, the processing vacuum chamber is evacuated by fully opening valve 12, and the hot element is heated up to a prescribed temperature and maintained at the temperature by the DC or AC power source 30. Next, valve 24 is opened and the cleaning gas is introduced into processing vacuum chamber 1. The pressure is set at a prescribed pressure by main valve 12.

10 The gas ejected from gas outlets 210 is effectively decomposed and/or activated by the platinum of the hot element which is maintained at a high temperature to generate activated species. For example, the hot element is preferably heated at 400°C and 1000°C or higher in the case of employing NF₃ and CF₄ as a cleaning gas. An activated species that is highly reactive with a deposited film can be generated by the catalytic action of the platinum. The platinum is stable against the activated species. Therefore, the stable film formation can be
15 carried out even after the cleaning treatment. The activated species reacts with the films deposited on the surface of the inner wall, the substrate holder and the like and converts the films into gaseous substances. The films are gradually removed as the gaseous substances thus generated are evacuated outside by the exhaust system.

20 This condition is maintained until the deposited films are completely removed. Thereafter, the supply of the cleaning gas and the energy to the hot element are stopped, and the processing vacuum chamber is evacuated. The cleaning process is completed in this way.

The cleaning procedure in this embodiment is an example of the cleaning method of this invention. One point of this invention is to carry out the cleaning in such that a cleaning
25 gas is introduced while the hot element is heated by introducing an electric current. Therefore, for example, any procedure or order of the valve operation and the pressure adjustment with valves 22, 24 and main valve 12 different from those mentioned in the embodiment can also be adopted, or a dummy substrate may be placed on substrate holder 4 in the cleaning process.

30 In addition, although the gas is introduced into the chamber through gas supply vessel 2 in Fig. 1, the cleaning gas can be introduced through a different route than that of a material gas or can be introduced through a nozzle.

The hot element can also be placed at different locations from that shown in Fig. 1, for example, inside the gas supply vessel.

Although the temperature of the objects to be treated such as the inner wall of processing chamber 1, substrate holder 4, and gas supply vessel 2 has not been mentioned in the above embodiment, such objects may be heated by a heater to increase the removal rate of deposited films and shorten the cleaning time, since the higher the temperature of these objects, the larger the reaction rate of the cleaning gas with deposited films.

On the other hand, deposited films can be removed without heating in such a short time as previously mentioned so that whether the objects are heated or not is a matter of choice of the cleaning condition.

Moreover, in the conventional method using a gas such as ClF_3 , a processing vacuum chamber must be heated in order to obtain practical removal rate of deposited films.

However, the heating treatment is not necessary in this invention as mentioned above, so that the time for heating and cooling the processing vacuum chamber which usually needs a long time can be omitted and therefore the substantial cleaning time can be remarkably shortened.

Hot element 3 is usually connected and fixed to current lead members (not illustrated) installed in the processing vacuum chamber. The current lead members are usually made of Mo or Cu and formed in rod or block shape. The electric current is applied to the hot element through current lead members from energy supply mechanism 30. The members react with the cleaning gas and are etched. However, this reaction will not influence the exothermic characteristic of the hot element at all since their cross sections are very large compared with that of the hot element.

It is possible to cover the surface of the current lead members with platinum to prevent the reaction with the cleaning gas. In this case, the coating of the platinum is made by a method of electron-beam evaporation, sputtering, plating, lining or the like in the same way as that used for the hot element.

The in-situ cleaning method of a hot element CVD apparatus has been described so far. The cleaning method of this invention is also available in the case of removing films deposited in other processing apparatuses or films deposited on various members. Here, the term "members" is meant to include a measuring instrument, a sensor, a valve and the like usually used in vacuum apparatuses.

Films adhered to the inside of a vacuum vessel, for example, are removed in the following way. A hot element, at least the surface of which is made of platinum, is installed in the vacuum vessel so that the element can be activated from outside. A cleaning gas inlet port is also provided to the vacuum vessel. A deposited film can be removed by heating the element to a prescribed temperature and introducing the cleaning gas into the vacuum vessel.

In the case of removing films deposited on members, the members are placed in such a vacuum vessel, and similar treatment is carried out. In the case of pipe with a considerable length, a hot element is placed at the upstream end of the pipe so that the gas is made flow inside the pipe. It is also possible to construct a vacuum vessel with pipes or members to be treated.

Even films deposited in narrow gaps of a member with complicated shapes or inside the pipe can be effectively removed by this invention as has been mentioned. This seems to be attributed to the activated species of cleaning gas that is generated to be very reactive and have a considerably long lifetime by a hot element made of platinum.

The removal method of the deposited film of this invention can be applied to various types of deposited films by appropriately selecting a cleaning gas and a cleaning condition. For example, when a cleaning gas containing fluorine or chlorine is used, various types of deposited films including metal films such as W, Ta and Ti can also be removed as well as semiconductors or insulators such as silicon, silicon carbide, and silicon nitride.

A cleaning gas is also selected according to the type of deposited film, the cleaning condition, or materials of the processing vacuum chamber. A fluorine- or chlorine-containing gas is suitably used. In particular, NF_3 , F_2 , Cl_2 , CF_4 , C_2F_6 , C_3F_8 , CCl_4 , C_2ClF_5 , ClF_3 , CClF_3 or SF_6 is preferably used. The gas can be diluted by, e.g., Ar or He, or can be mixed for practical use.

A hot element is used in a variety of shapes such as a wire, rod, tube, plate, foil or the like. A wire may be further formed into coil or saw tooth shape.

In a hot element CVD apparatus of this invention, an electrode for plasma generation can be disposed inside the processing vacuum chamber. The plasma discharge of fluorine- or chlorine-containing cleaning gases can be made to occur in the cleaning process with the hot element heated by an electric current. The cleaning gas is decomposed and/or activated by the plasma, enabling removal of a film deposited inside the processing chamber. It is confirmed that the hot element of this invention does not practically react with plasma.

Accordingly, an in-situ cleaning using plasma becomes available, in which the processing chamber does not need to be exposed to the atmosphere during the cleaning.

In addition, both the heating of the hot element and the plasma generation can be carried out at the same time in the film formation process and the cleaning process. The interaction of the heat by the hot element and the plasma further improves the film characteristics and the cleaning efficiency.

In the case of using ClF_3 as a cleaning gas and heating a processing chamber or a member to decompose the gas, an in-situ cleaning is also available so long as materials of the chamber or member to be treated permit since the hot element is stable against the ClF_3 .

(Application to the Industry)

The present invention makes it possible to provide a method for effectively removing films deposited inside various film forming chambers and on the members by heating a hot element made of platinum at the surface to a prescribed temperature, and introducing a cleaning gas.

In addition, a hot element CVD apparatus which an in-situ cleaning is applied to is realized. As a result, a continuous production of thin films having high characteristics become available by a hot element CVD method which is expected to be a promising manufacturing means of high characteristic films.

Thus, the present invention contributes to further improvement of the characteristics and productivity of semiconductor devices and display devices, and also promotes their development.

While this invention has been described as having an exemplary design, the present invention may be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains.

VERIFICATION OF TRANSLATION

Date : July 19, 2000

I, Jiro Nakanishi, do solemnly and sincerely declare that the translation of Japanese Application No. 11-222088 into English was performed by me, a competent translator, conversant with the English and Japanese languages, and that it is a true and accurate translation to the best of our knowledge and ability of the Japanese Application submitted to Nakanishi Patent Office for translating into English.

Jiro Nakanishi

Jiro Nakanishi

【Document】 Specification

【Title of Invention】 A hot element CVD apparatus and a method for removing a deposited film

【Claims】

【Claim 1】 A method for removing a film deposited inside a chamber which can be exhausted and/or on a member placed in said chamber characterized in that after said chamber is exhausted, a hot element, at least the surface of which is composed of platinum, disposed in said vacuum chamber, is heated at a prescribed temperature and a cleaning gas which is decomposed and/or activated by said hot element to generate an activated species that converts said film into gaseous substance is introduced into said chamber.

【Claim 2】 The method according to claim 1, wherein said chamber is of a CVD apparatus which decomposes and/or activates the material gas by said hot element and deposits a film containing at least one element from said material gas on a substrate.

【Claim 3】 The method according to claim 1 or 2, wherein said cleaning gas is a gas containing at least one of fluorine (F_2), chlorine (Cl_2), nitrogen trifluoride (NF_3), carbon tetrafluoride (CF_4), hexafluoroethane (C_2F_6), octafluoropropane (C_3F_8), carbon tetrachloride (CCl_4), pentafluorochloroethane (C_2ClF_5), trifluorochlorine (ClF_3), trifluorochloromethane ($CClF_3$), sulfur hexafluoride (SF_6) or mixtures thereof.

【Claim 4】 A Hot element CVD apparatus for forming a film containing at least one element from a material gas on a substrate, comprising a process chamber which can be exhausted, an inlet of said material gas, and a hot element able to be set at a prescribed temperature disposed in said chamber, said material gas decomposed and/or activated by said hot element,

wherein at least the surface of said hot element is composed of platinum and a gas supply system of a cleaning gas which is decomposed and/or activated by said hot element to generate an activated species which converts a film deposited inside said chamber to gaseous substance, is provided so as to remove said deposited film without exposing the inside of said chamber

to the atmosphere.

【Claim 5】 The Hot element CVD apparatus according to claim 4, wherein an electrode for plasma generation is disposed in said chamber.

【Detailed description of the invention】

【0001】

【Technical field which the invention pertain to】

This invention relates to a CVD apparatus for forming a film by using a hot element set at a prescribed temperature and a method for removing a deposited film, and particularly to a Hot element CVD apparatus which an in-situ cleaning is applied to and its cleaning method.

【0002】

【Background of the Invention】

In the manufacturing process of semiconductor devices such as an LSI (large scale integrated circuit), display devices such as an LCD (liquid crystal display) and the like, a chemical vapor deposition (CVD) method is widely used for forming a variety of thin films on a substrate.

【0003】

As such a CVD method, a plasma CVD method which utilizes a plasma to decompose and/or activate a material gas to form a film on a substrate and a thermal CVD method which utilizes the heat of a substrate to cause a reaction of a material gas and form a film on a substrate are well known. In addition to these methods, there is another CVD method in which a material gas is decomposed and/or activated to form a film by a hot element set at a prescribed high temperature. This CVD method is called "a Hot element CVD method" hereinafter.

【0004】

A CVD apparatus to carry out this method is constructed in such that a hot element made of metal having a high melting point such as tungsten and a substrate are disposed in a processing vacuum chamber, and a material gas is introduced into the chamber while the hot element is maintained at a temperature of about 1000-1800°C. The material gas introduced in the chamber

is decomposed and/or activated to generate activated species when passing over the surface of the hot element. The activated species reaches the substrate and forms a thin film on the surface of the substrate. Of such a hot element CVD method, one using a wire as a hot element is referred to as a Hot-Wire CVD method, and the one that is thought to be utilizing the catalytic reaction of a hot element in decomposition or activation process of the material gas is referred to as a Catalytic-CVD (or Cat-CVD) method.

【0005】

In the Hot element CVD method, the decomposition or activation reaction of the material gas occurs when the gas passes over the surface of the hot element. Therefore, the substrate temperature can be lowered as compared with a thermal CVD method in which such a reaction is caused to occur only by the heat of the substrate. And unlike a plasma CVD method, the substrate is free from the damages caused by plasma. For these reasons, the hot element CVD method is expected to be a promising film forming method of semiconductor devices and display devices of the next generation, which will have higher integration and higher functions.

【0006】

As the film formation is made on a substrate, a film is also deposited on the inner structures of the film forming apparatus in any film forming method including CVD methods mentioned above. The film deposited on the inner structures peels off when it becomes thick, which produces particles. The particles thus produced may be incorporated in the film on the substrate or adhere to the surface of the film, which causes the defect in the device and reduces production yield of the device.

In order to avoid these problems, the deposited film on the inner structures should be periodically removed before peeling off in the repetition of film formation.

【0007】

One method often used for preventing the generation of particles due to the peeling-off of the deposited film is to cover the inner surfaces of the

apparatus with sheets or members on which the films can be deposited instead of on inner surfaces in the apparatus and to periodically exchange these sheets or members. However, since the deposition takes place even inside the narrow gaps of inner structure or on the hidden side of the sheets or members in the case of, e.g., the CVD apparatus. It is impossible to completely prevent the generation of particles.

【0008】

In contrast, as a method for removing a film deposited inside the film forming chamber, there is a method called an in-situ cleaning method in which a cleaning gas is introduced into the chamber and is made to react with deposited films with the aid of energy of plasma or heat to generate gaseous substances which can be exhausted.

Since the in-situ cleaning method is carried out without exposing the inside of the chamber to the atmosphere, the continuous and stable production of thin films having a prescribed characteristic becomes available. In addition, since neither the exchange of the sheets or members nor the operation of exhausting the chamber from the atmospheric pressure to a prescribed pressure is necessary, the time for the cleaning process is remarkably shortened. Thus, this method has an advantage in increasing the productivity.

Moreover, this method makes it possible to remove even the film deposited inside the narrow gaps and effectively suppress the generation of particles.

【0009】

When the in-situ cleaning method is applied to a plasma CVD apparatus used for forming, for example, a silicon film or a silicon nitride film, a cleaning gas such as NF_3 , CF_4 or CCl_4 is introduced into the processing chamber and the plasma is generated at a proper time after the film formation has been repeatedly carried out. The cleaning gas is decomposed and/or activated by the plasma to react with a deposited film. A silicon film is converted to silicon tetrafluoride (SiF_4) or silicon tetrachloride (SiCl_4) and a silicon nitride film is to SiF_4 or SiCl_4 and nitrogen (N_2). Since these gaseous substances are to be exhausted, the deposited film, consequently, can be removed.

In contrast, when a cleaning gas such as ClF_3 that is easily decomposed by heat is employed, plasma is not necessary. The deposited film can also be converted to gaseous substances merely by heating the chamber. However, the chamber must be heated above 200 °C in order to obtain a practical removal rate, which may cause the degradation of vacuum seals and substantially lengthens the cleaning time because it takes long time to heat and cool the chamber.

【0010】

【Problems to be solved by the invention】

As has been mentioned, the in-situ cleaning of the film forming chamber is very important process that is used to stabilize and continuously form a film with prescribed characteristics. Therefore, the present inventor attempted to apply the in-situ cleaning method to a promising hot element CVD apparatus and found that the conventional in-situ cleaning methods have a problem in that a hot element made of metal having a high melting point reacts with the cleaning gas, and the wire becomes thin. That is, in this attempt, there were placed electrodes for the plasma generation in the processing chamber, the cleaning gas was introduced and then plasma is generated to carry out the cleaning. Although the deposited film could be removed, the hot element was also etched so that its diameter decreases. As a result, the prescribed exothermic characteristics could not be obtained in the next film formation.

【0011】

A ClF_3 gas as a cleaning gas was introduced into the film forming chamber which was heated to 200°C by using a heater installed outside. The hot element similarly reacted with the cleaning gas and its diameter decreased.

【0012】

Thus, conventional in-situ cleaning methods cannot be directly applied to a hot element CVD apparatus. However, since in-situ cleaning is desired for the continuous and stable production of films, further examinations on the structure of the Hot element CVD apparatus and the cleaning condition were made to establish in-situ cleaning technology is applicable to the Hot element CVD

apparatus.

【0013】

This invention has been completed for the first time based on the above-mentioned knowledge and discovery. An object of this invention is to provide a method for efficiently and completely removing a film deposited even on the surface of a member having a complicated shape without providing a heating means for heating the member.

Another object of this invention is to provide an in-situ cleaning method for a Hot element CVD apparatus which enables removal of a film deposited inside the apparatus without allowing the inside of the apparatus to be exposed to the atmosphere. Another purpose of this invention is to provide a hot element CVD apparatus to which an in-situ cleaning is applied,

【0014】

【Means for solving the problem】

A method for removing a deposited film according to the present invention comprises a method for removing a film deposited inside a chamber, which chamber can be exhausted and/or have a member placed therein, wherein after said chamber is exhausted, a hot element, at least the surface of which is composed of platinum, disposed in said chamber, is heated to a prescribed temperature and a cleaning gas which is decomposed and/or activated by said hot element to generate an activated species that converts said film into a gaseous substance is introduced into said chamber

【0015】

The chamber is part of a CVD apparatus which decomposes and/or activates a material gas by said hot element and deposits a film containing at least one element of said material gas on a substrate.

【0016】

By making the surface of a hot element with platinum, it becomes possible to substantially prevent the reaction of the cleaning gas with the hot element and therefore prevent any decrease in, e.g., the diameter of, the hot element. Moreover, a hot element that is made of platinum at least at its surface, makes it

possible to efficiently decompose and/or activate the cleaning gas and generate activated species at a relatively low temperature and thereby effectively remove films deposited inside the chamber. The activated species thus generated seems to have such a long lifetime that even films deposited on a complicated shape or the inside of the pipe can be removed. In addition, the in-situ cleaning which is desired for the continuous formation of films with high characteristics can be applied to a hot element CVD apparatus.

【0017】

In this invention, said cleaning gas comprises fluorine (F_2), chlorine (Cl_2), nitrogen trifluoride (NF_3), carbon tetrafluoride (CF_4), hexafluoroethane (C_2F_6), octafluoropropane (C_3F_8), carbon tetrachloride (CCl_4), pentafluorochloroethane (C_2ClF_5), trifluorochlorine (ClF_3), trifluorochloromethane ($CClF_3$), or sulfur hexafluoride (SF_6).

【0018】

These gases are sufficiently decomposed and/or activated with the aid of a hot element set at a prescribed temperature, and convert the deposited films to gaseous substances, resulting in efficiently removing the deposited film.

【0019】

A CVD apparatus of this invention comprises a hot element CVD apparatus for forming a film containing at least one element of a material gas on a substrate. The CVD apparatus includes a process chamber able to be exhausted, an inlet for material gas, and a hot element able to be set at a prescribed temperature disposed in said chamber. In use, said material gas is decomposed and/or activated by said hot element. At least the surface of said hot element is composed of platinum. The CVD apparatus also included a gas supply system that supplies a cleaning gas which is decomposed and/or activated by said hot element to generate activated species which converts a film deposited inside said chamber to a gaseous substance which is removed without exposing the inside of said chamber to the atmosphere.

【0020】

In this invention, the hot element is fabricated so as not to react with a

cleaning gas. This makes it possible to carry out the cleaning only by introducing the cleaning gas and heating said hot element after film formations. Accordingly, an in-situ cleaning of the apparatus can be realized.

【0021】

An electrode for plasma generation may be disposed in said chamber. Since the hot element will not react with a cleaning gas or plasma, a conventional plasma cleaning method can be employed. Moreover, in the decomposition or activation of the gas, both the plasma and the heat of the hot element may be simultaneously employed. This increases the degree of freedom of the film formation and cleaning conditions, and therefore contributes to further improvements of film characteristics and cleaning efficiency.

【0022】

【Preferred Embodiments of the Invention】

The preferred embodiments of this invention will be described below by referring to the accompanying drawings.

Fig.1 is a conceptual diagram showing a structural example of a hot element CVD apparatus, in which apparatus an in-situ cleaning method according to the present invention is applied to.

【0023】

A film forming apparatus shown in Fig.1 comprises a processing vacuum chamber 1, an exhaust system 11 for exhausting the processing vacuum chamber 1, gas supplying systems 23,25 for supplying a material gas for the film formation and a cleaning gas, and a gate valve 5 through which a substrate is transferred. In processing vacuum chamber 1, surfaces of a gas supply vessel 2 connected with gas supply system 23,25, a substrate holder 4, and a hot element 3, are made of platinum.

【0024】

The introduction of a material gas and a cleaning gas to gas supply vessel 2 is switched by valves 22,24. The feed rate of these gases is controlled by a respective flow controller (not illustrated) provided in each of gas supply systems 23, 25. Gas supply vessel 2 has a hollow structure and a plurality of gas outlets

210 in the plane that faces to substrate holder 4. The exhaust system 11 is connected to processing vacuum chamber 1 through a main valve 12 having an exhaust speed regulation function by which the pressure inside the processing chamber is controlled.

【0025】

A support member 31 holds hot element 3 that is connected to an energy supply mechanism 30 for controlling the temperature of hot element 3. As an energy supply mechanism, a DC or AC power source is, in general, employed. The hot element is heated and maintained at a prescribed temperature by an electric current to decompose and/or activate a material gas during a film formation process and a cleaning gas during a cleaning process, which efficiently brings about the film formation and the cleaning.

【0026】

Fig.2 is a conceptual plan view showing a configuration of hot element 3 shown in Fig. 1. In this case, hot element 3 is fabricated with a wire member formed in saw tooth shape and is held by a support member 31.

【0027】

The hot element that has a platinum layer on the surface of a substrate member is described in detail by referring to Fig.3. Fig. 3 is a sectional view of hot element 3 taken along the a-a' line of Fig.2.

As shown in Fig.3, the hot element comprises a substrate member 301 and a coating layer 302 formed thereon. There is no particular restriction on the material of the substrate member, but a material which has a higher melting point than platinum is preferably employed such as tungsten, tantalum, niobium, carbon, iridium, molybdenum or rhodium, silicon carbide, PBN (pyrolytic boron nitride), alumina and the like. The coating layer 302 of platinum is formed by a method of electron-beam evaporation, sputtering, plating, lining or the like.

It is also possible to make whole hot element with platinum.

【0028】

Next, the method of the film formation and the cleaning will be explained by using the apparatus shown in Fig.1.

(Film formation)

First, a substrate is transferred into processing vacuum chamber 1 through gate valve 5 from a load lock chamber (not illustrated) and is placed on substrate holder 4. After processing vacuum chamber 1 is evacuated to a prescribed pressure by exhaust system 11, energy is supplied to hot element 3 from a DC or AC power source as an energy supply mechanism 30 to maintain hot element at a prescribed temperature. This temperature is usually determined, depending on the type of a film to be formed and a material gas; for example, a temperature around 1000°C is used for forming a silicon film with silane (SiH_4) and hydrogen (H_2).

【0029】

Then, valve 22 is opened and the material gas is introduced into the processing vacuum chamber at a prescribed flow rate. The pressure inside the processing vacuum chamber is set at a prescribed pressure by the exhaust speed regulation function of main valve 12.

The material gas supplied into gas supply vessel 2 is blown off through gas outlets 210 in the direction of hot element 3, and is decomposed and/or activated by the catalytic action of the platinum of the hot element maintained at a high temperature to generate activated species. The activated species reaches the substrate and the film is deposited on it. When the thickness of the film on the substrate reaches a predetermined value, the material gas and the energy to the hot element are cut off. After the chamber is evacuated, the substrate is carried to the load lock chamber through gate valve 5 to finish the film formation.

【0030】

(Cleaning)

The repetition of the film formation mentioned above also causes the film to be deposited on the inner surface of the processing vacuum chamber, the substrate holder, the gas supply vessel, the support member and the like. When this deposited film becomes thick, it will peel off to produce particles. The particles may be entrapped in the film during the film formation or may adhere to the surface of the film, which deteriorates the characteristics of the film or causes

defects in devices. Therefore, the following cleaning treatment should be made before the film becomes thick and begins to peel off and produce particles. The film thickness of a deposited film may be monitored with the aid of an optical sensor or be estimated from the total film forming time.

【0031】

In the cleaning process, the processing vacuum chamber is evacuated by fully opening valve 12, and the hot element is heated up to a prescribed temperature and maintained at the temperature by the DC or AC power source 30. Next, valve 24 is opened and the cleaning gas is introduced into processing vacuum chamber 1. The pressure is set at a prescribed pressure by main valve 12.

【0032】

The gas ejected from gas outlets 210 is effectively decomposed and/or activated by the platinum of the hot element which is maintained at a high temperature to generate activated species. For example, the hot element is preferably heated at 400°C and 1000°C or higher in the case of employing NF_3 and CF_4 as a cleaning gas. An activated species that is highly reactive with a deposited film can be generated by the catalytic action of the platinum. The platinum is stable against the activated species. Therefore, the stable film formation can be carried out even after the cleaning treatment. The activated species reacts with the films deposited on the surface of the inner wall, the substrate holder and the like and converts the films into gaseous substances. The films are gradually removed as the gaseous substances thus generated are evacuated outside by the exhaust system.

【0033】

This condition is maintained until the deposited films are completely removed. Thereafter, the supply of the cleaning gas and the energy to the hot element are stopped, and the processing vacuum chamber is evacuated. The cleaning process is completed in this way.

【0034】

The cleaning procedure in this embodiment is an example of the cleaning

method of this invention. One point of this invention is to carry out the cleaning in such that a cleaning gas is introduced while the hot element is heated by introducing an electric current. Therefore, for example, any procedure or order of the valve operation and the pressure adjustment with valves 22,24 and main valve 12 different from those mentioned in the embodiment can also be adopted, or a dummy substrate may be placed on substrate holder 4 in the cleaning process.

In addition, although the gas is introduced into the chamber through gas supply vessel 2 in Fig.1, the cleaning gas can be introduced through a different route from that of a material gas or can be introduced through a nozzle.

The hot element can also be placed at different locations from that shown in Fig.1, for example, inside the gas supply vessel.

【0035】

Although the temperature of the objects to be treated such as the inner wall of processing chamber 1, substrate holder 4, and gas supply vessel 2 has not been mentioned in the above embodiment, such objects may be heated by a heater to increase the removal rate of deposited films and shorten the cleaning time, since the higher the temperature of these objects, the larger the reaction rate of the cleaning gas with deposited films.

On the other hand, deposited films can be removed without heating in such a short time as previously mentioned that whether the objects are heated or not is a matter of choice of the cleaning condition.

Moreover, in the conventional method using a gas such as ClF_3 , a processing vacuum chamber must be heated in order to obtain practical removal rate of deposited films. However the heating treatment is not necessary in this invention as mentioned above, so that the time for heating and cooling the processing vacuum chamber which usually needs a long time can be omitted and therefore the substantial cleaning time can be remarkably shortened.

【0036】

The in-situ cleaning method of a hot element CVD apparatus has been described so far. The cleaning method of this invention is also available in the

case of removing films deposited in other processing apparatuses or films deposited on various members. Here, the members are meant to include a measuring instrument, a sensor, a valve and the like usually used in vacuum apparatuses.

【0037】

Films adhered to the inside of a vacuum vessel, for example, are removed in the following way. A hot element, at least the surface of which is made of platinum, is installed in the vacuum vessel so that the element can be activated from outside. A cleaning gas inlet port is also provided to the vacuum vessel. A deposited film can be removed by heating the element to a prescribed temperature and introducing the cleaning gas into the vacuum vessel.

In the case of removing films deposited on members, the members are placed in such a vacuum vessel, and similar treatment is carried out. In the case of pipe with a considerable length, a hot element is placed at the upstream end of the pipe so that the gas is made flow inside the pipe. It is also possible to construct a vacuum vessel with pipes or members to be treated.

【0038】

Even films deposited in narrow gaps of a member with complicated shapes or inside the pipe can be effectively removed by this invention as has been mentioned. This seems to be attributed to the activated species of cleaning gas that is generated to be very reactive and have a considerably long lifetime by a hot element made of platinum.

【0039】

The removal method of the deposited film of this invention can be applied to various types of deposited films by appropriately selecting a cleaning gas and a cleaning condition. For example, when a cleaning gas containing fluorine or chlorine is used, various types of deposited films including metal films such as W, Ta and Ti can also be removed as well as semiconductors or insulators such as silicon, silicon carbide, and silicon nitride.

【0040】

A cleaning gas is also selected according to the type of deposited film, the

cleaning condition, or materials of the processing vacuum chamber. A fluorine- or chlorine-containing gas is suitably used. In particular, NF_3 , F_2 , Cl_2 , CF_4 , C_2F_6 , C_3F_8 , CCl_4 , C_2ClF_5 , ClF_3 , CClF_3 or SF_6 is preferably used. The gas can be diluted by, e.g., Ar or He or can be mixed for practical use.

【0041】

A hot element is used in a variety of shapes such as a wire, rod, tube, plate, foil or the like. A wire may be further formed into coil or saw tooth shape.

【0042】

In a Hot element CVD apparatus of this invention, an electrode for plasma generation can be disposed inside the processing vacuum chamber. The plasma discharge of fluorine- or chlorine-containing cleaning gases can be made to occur in the cleaning process with the hot element heated by an electric current. The cleaning gas is decomposed and/or activated by the plasma, enabling removal of a film deposited inside the processing chamber. It is confirmed that the hot element of this invention does not practically react with plasma. Accordingly, an in-situ cleaning using plasma becomes available, in which the processing chamber does not need to be exposed to the atmosphere at the cleaning.

In addition, both the heating of the hot element and the plasma generation can be carried out at the same time in the film formation process and the cleaning process. The interaction of the heat by the hot element and the plasma further improves the film characteristics and the cleaning efficiency.

【0043】

In the case of using ClF_3 as a cleaning gas and heating a processing chamber or a member to decompose the gas, an in-situ cleaning is also available so long as materials of the chamber or member to be treated permit since the hot element is stable against the ClF_3 .

【0044】

【Effect of the invention】

The present invention makes it possible to provide a method for effectively

removing films deposited inside various film forming chambers and on the members by heating a hot element made of platinum at the surface to a prescribed temperature, and introducing a cleaning gas.

In addition, a hot element CVD apparatus which an in-situ cleaning is applied to is realized. As a result, a continuous production of thin films having high characteristics become available by a hot element CVD method which is expected to be a promising manufacturing means of high characteristic films.

Thus, the present invention contributes to further improvement of the characteristics and productivity of semiconductor devices and display devices, and also promotes their development.

【Brief description of the drawing】

【Figure 1】

Fig.1 is a conceptual diagram showing a configuration example of a film forming apparatus employing a Hot element CVD method, in which apparatus an in -situ cleaning according to the present invention is applied to.

【Figure 2】

Fig.2 is a conceptual plan view showing a configuration of hot element 3 shown in Fig. 1.

【Figure 3】

Fig. 3 is s sectional view of hot element 3 taken along the a-a' line.

【Description of the code】

- 1; processing vacuum chamber,
- 2; gas supply vessel,
- 3; hot element,
- 4; substrate holder,
- 11; exhaust system,
- 12; main valve,
- 22; valve,
- 23; material gas supply system,
- 24; valve,
- 25; cleaning gas supply system,

30; energy supply mechanism,

31; support member,

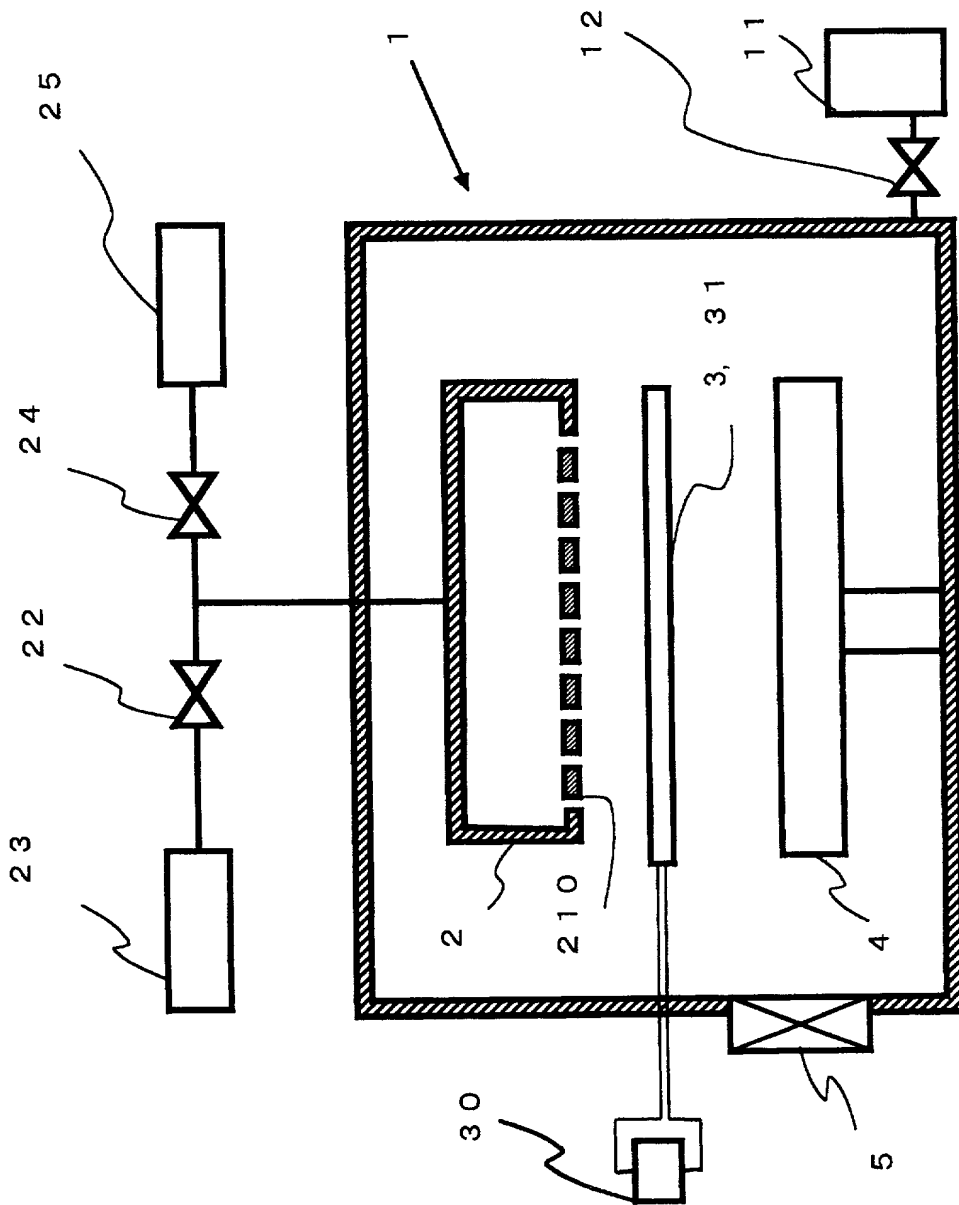
201; gas outlet,

301; substrate member,

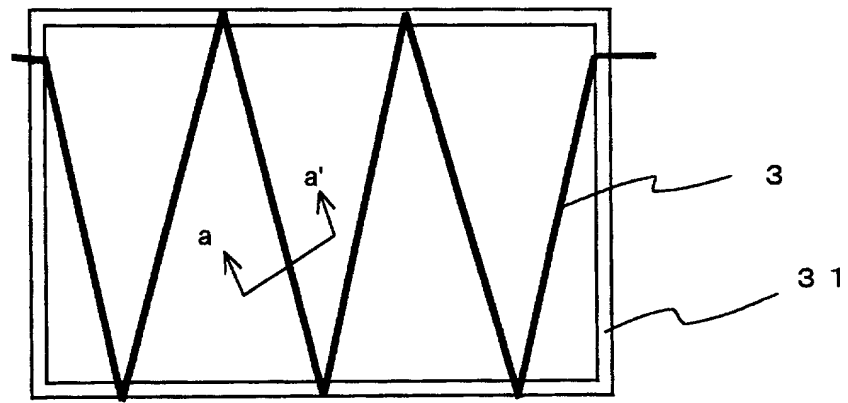
302; platinum coating.

JP application No. 11-222088

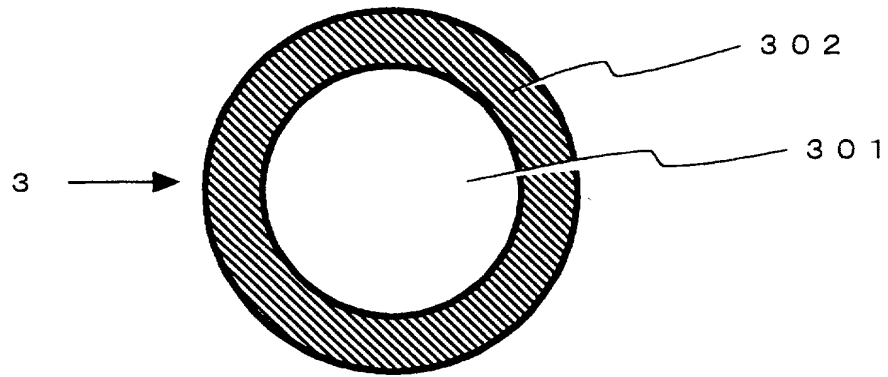
Fig. 1



F i g . 2



F i g . 3



Declaration and Power of Attorney for Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

私は、以下に記名された発明者として、ここに下記の通り宣言する：

As a below named inventor, I hereby declare that:

私の住所、郵便の宛先そして国籍は、私の氏名の後に記載された通りである。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明について、特許請求範囲に記載され、且つ特許が求められている発明主題に関して、私は、最初、最先且つ唯一の発明者である（唯一の氏名が記載されている場合）か、或いは最初、最先且つ共同発明者である（複数の氏名が記載されている場合）と信じている。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

A HOT ELEMENT CVD APPARATUS AND

A METHOD FOR REMOVING A DEPOSITED FILM

上記発明の明細書はここに添付されているが、下記の欄がチェックされている場合は、この限りでない：

the specification of which is attached hereto unless the following box is checked:

☐ _____ の日に出願され、
この出願の米国出願番号またはPCT国際出願番号は、
_____ であり、且つ
_____ の日に補正された出願（該当する場合）

☐ was filed on _____
as United States Application Number or
PCT International Application Number
_____ and was amended on
_____ (if applicable).

私は、上記の補正書によって補正された、特許請求範囲を含む上記明細書を検討し、且つ内容を理解していることをここに表明する。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編規則1.56に定義されている、特許性について重要な情報を開示する義務があることを認める。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56

Japanese Language Declaration (日本語宣言書)

私は、ここに、以下に記載した外国での特許出願または発明者証の出願、或いは米国以外の少なくとも一国を指定している米国法典第35編第365条(a)によるPCT国際出願について、同第119条(a)-(d)項又は第365条(b)項に基づいて優先権を主張するとともに、優先権を主張する本出願の出願日より前の出願日を有する外国での特許出願または発明者証の出願、或いはPCT国際出願については、いかなる出願も、下記の枠内をチェックすることにより示した。

I hereby claim foreign priority under Title 35, United States Code, Section 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application for which priority is claimed.

Prior Foreign Application(s)

外国での先行出願

Priority Not Claimed

優先権主張なし

11-222088

Japan

05/08/1999

(Number)
(番号)

(Country)
(国名)

(Day/Month/Year Filed)
(出願日/月/年)

☐

(Number)
(番号)

(Country)
(国名)

(Day/Month/Year Filed)
(出願日/月/年)

☐

私は、ここに、下記のいかなる米国仮特許出願についても、その米国法典第35編第119条(e)項の利益を主張する。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.)
(出願番号)

(Filing Date)
(出願日)

(Application No.)
(出願番号)

(Filing Date)
(出願日)

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I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of application.

(Application No.)
(出願番号)

(Filing Date)
(出願日)

(Status: Patented, Pending, Abandoned)
(現況: 特許許可、係属中、放棄)

(Application No.)
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(Filing Date)
(出願日)

(Status: Patented, Pending, Abandoned)
(現況: 特許許可、係属中、放棄)

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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委任状: 私は本出願を審査する手続を行い、且つ米国特許商標庁との全ての業務を遂行するために、記名された発明者として、下記の弁護士及び/または弁理士を任命する。(氏名及び登録番号を記載すること)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number).

書類送付先

Anthony Niewyk, Regis. No. 24, 871; John F. Hoffman, Regis. No. 26, 280; Kevin R. Erdman, Regis. No. 33, 687; Michael D. Smith, Regis. No. 40, 181; Scott M. Lohnes, Regis. No. 45, 451; and Michael D. Schwartz, Regis. No. 44, 326.
Send correspondence to:
Anthony Niewyk
BAKER & DANIELS
111 East Wayne Street, Suite 800
Fort Wayne, IN 46802

直通電話連絡先: (氏名及び電話番号)

Direct Telephone Calls to: (name and telephone number)

Anthony Niewyk,
Phone: 219-424-8000
FAX: 219-460-1727

第一または第一発明者氏名

Full name of sole or first inventor

Keiji ISHIBASHI

発明者の署名

日付

Inventor's signature

Date

Keiji Ishibashi July 26, 2000

住所

Residence

Tokyo, Japan

国籍

Citizenship

Japan

郵便の宛先

Post Office Address

1181-103, Kotta, Tama-shi, Tokyo,

Japan

第二共同発明者がいる場合、その氏名

Full name of second joint inventor, if any

第二共同発明者の署名

日付

Second inventor's signature

Date

住所

Residence

国籍

Citizenship

郵便の宛先

Post Office Address

(第三以下の共同発明者についても同様に記載し、署名すること)

(Supply similar information and signature for third and subsequent joint inventors.)